RESEARCH DEPARTMENT

THE MEASUREMENT OF NOISE GENERATED IN MICROPHONES BY WIND

Report No. L-035

(1957/11)

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SUMMARY

Serious interference with broadcast transmissions can be caused by the action of wind upon microphones. Microphones vary in their susceptibility to wind and for comparative purposes it is necessary to measure the amount of wind noise generated by an air stream. The report describes various methods of carrying out this measurement; results obtained by the use of a whirling arm are given for a number of commercial microphones.

1. INTRODUCTION

When a microphone is exposed to wind, fluctuations in air pressure are set up which, being of the same nature as sound, produce at the output terminals an unwanted e.m.f., referred to as wind noise. This noise, when reproduced on a loudspeaker, gives a low-pitched rumble bearing no resemblance to the characteristic whistling sound normally heard when an air stream impinges on an obstacle. Unless the wind-noise e.m.f. is small compared with the e.m.f. generated by the wanted sound, it may cause serious interference with the transmission.

The degree of interference produced by wind varies with different types of microphone and can often be considerably mitigated by the use of protective shields. In order to compare the noise generated by wind in different microphones or the efficacy of different windshields, it is necessary to produce an air stream of known velocity and free from turbulence, without at the same time generating too much ambient sound. This report describes the methods used to produce such an air stream and in particular a whirling-arm system. The results of measurements on a number of microphones are also given.

2. HISTORICAL

Little information has been published, either on the mechanism by which wind noise is generated or on methods of measuring this noise. There are several methods of producing a controlled air flow past a microphone but each has its disadvantages. In one technique employed in 1938[1], the wind was produced by a two-bladed propeller inside a short tube, but the measurements were found to be seriously affected by turbulence in the air stream. In this connection it is worth noting that some rough experiments, performed by Research Department, employing a simple electric blower showed that the errors introduced by turbulence could be as much as 30 dB; similarly, tests made from a moving vehicle were found to be unreliable. For these reasons, various methods of obtaining a more streamlined air flow have been investigated.

2.1. Pendulum Method

The first wind-noise measurements made in Research Department were carried out in 1949 on the type AXBT microphone using a pendulum method; later, other microphones[2, 3] were also tested in this way. The microphone is attached to the end of a cord or light rod to form a pendulum, from whose length and amplitude of oscillation the maximum velocity may be calculated. As the desired velocity is only reached for a small fraction of the time of one swing, the total time needed for a measurement is correspondingly large. For measurements at low velocities, the method has the advantage that the ambient sound level can be very low, since no machinery is involved, and that the air stream can be reasonably free of turbulence. Some tests, however, require wind speeds up to 40 m.p.h. (64 km/h), and it would be very difficult to obtain a room large enough to provide, in still air, the necessary length of pendulum.

2.2. Wind Tunnel Method

One method of producing high wind velocities is to use some form of wind tunnel which must provide a streamlined air flow over an area great enough to accommodate not only the microphone but a dummy head to simulate the effect of the user's head on the air stream. The size and cost of a tunnel to satisfy these requirements are prohibitive, and the acoustic noise generated by the associated machinery is normally very high unless special and usually costly measures are taken.

In the absence of a suitable wind tunnel, the method at present used in Research Department for measurements at high wind speeds is to attach the microphone to the end of a whirling arm.

3. DESCRIPTION OF WHIRLING-ARM MACHINE

Fig. 1 shows a general view of the machine. The microphone is mounted on a horizontal arm rotated about a vertical axis by an electric motor and gear box. By varying the length of the arm and the motor speed, the peripheral velocity may be adjusted from 2 m.p.h. to 40 m.p.h. (3·2 km/h to 64 km/h). Since the same circular path is repeatedly traversed it is desirable that turbulence generated by the passage of the microphone through the air during one rotation should have time to disperse before the next rotation. For a given air speed, therefore, the angular velocity is restricted to a maximum of 2 rev/sec, and the greatest possible length of arm is used. Under these conditions the results obtained are substantially in agreement with those from a large wind tunnel.

The electrical connections from the microphone are taken to contacts which rotate in troughs of mercury concentric with the vertical shaft so that with this type of connection no troublesome contact noise is generated.

The lowest speed at which the machine can be usefully employed is determined by the signal generated in the microphone by mechanical vibration and ambient noise. As a precaution against accidents it was decided to mount the whirling arm in an empty room having strong doors and no windows; these requirements were met by an existing reverberation chamber but it was necessary to introduce acoustic absorbent material into the room to reduce the level of the sound produced by the motor and gear box. It was also essential to isolate the microphone from structure-borne vibration. With these precautions the unwanted output from the microphone due to all causes did not exceed that produced by a sound level of + 39 dB with reference to 0·0002 dyne/cm^2 at 1 kc/s.

4. MEASUREMENTS ON MICROPHONES

Measurements of wind noise have been made, employing the whirling arm, with a number of types of microphone which are commonly used out of doors and the effectiveness of different kinds of windshield has been assessed. When testing close-talking instruments, measurements were also made of the effect of the disturbance produced by an artificial head mounted, with the microphone, as shown in Fig. 1, on the rotating arm.

The noise output was weighted with the standard A.S.A. weighting network and measured by a V.U. meter; the results are expressed in the table overleaf as the level with respect to 0·0002 dyne/cm^2 of a 1 kc/s tone which is calculated to give an equivalent signal.

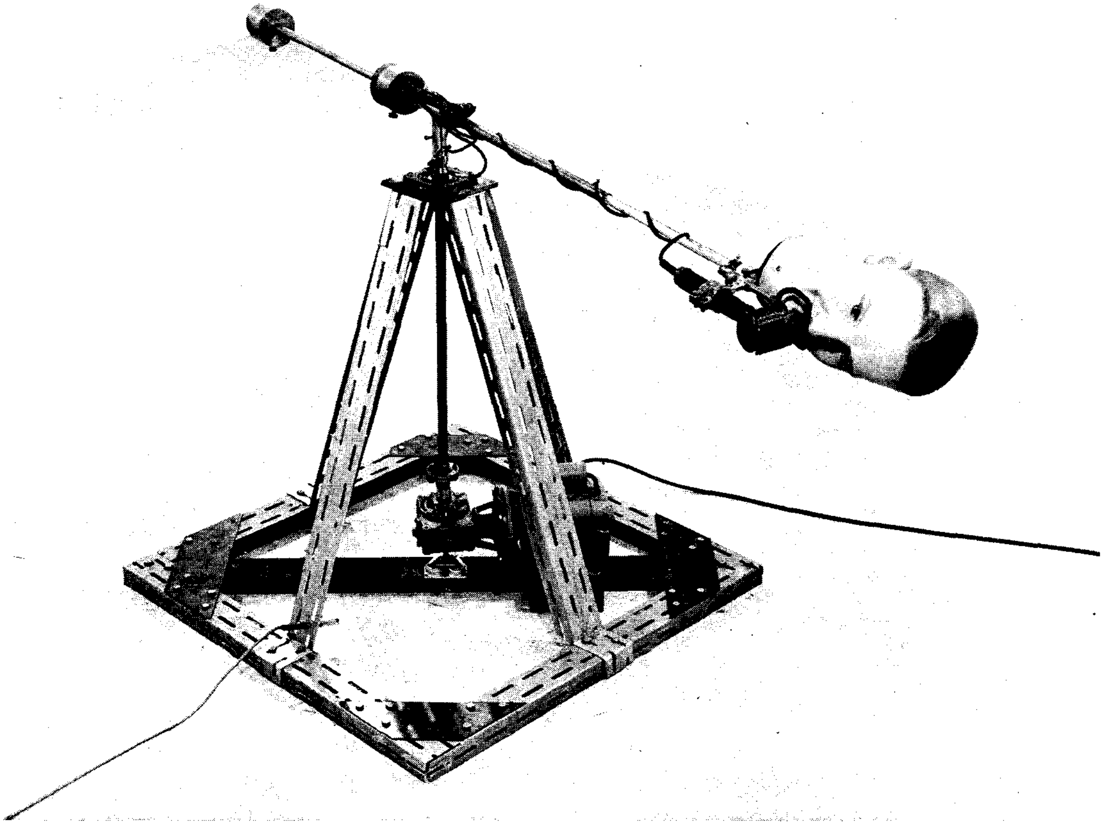

Fig. 1

Microphone	Sound Level at 1 kc/s to give Open-Circuit Output equal to Weighted Noise Output of Microphone		Reduction in Noise by Windshield dB		Remarks
	20 m.p.h. (32 km/h)	40 m.p.h. (64 km/h)	20 m.p.h. (32 km/h)	40 m.p.h. (64 km/h)	
L.2 without windshield. With dummy head	45 to 55	61 to 83			Noise minimum for 0°, maximum for 180° incidence
L.2 with cloth-covered windshield. With dummy head	36 to 42	47 to 53	6 to 15	14 to 30	Windshield most effective for 90° and 180° incidence
L.2 without windshield	47 to 50	57 to 69			
L.2 with cloth-covered windshield	30 to 33	46	13 to 18	11 to 23	
L.2 with plastic-covered waterproof windshield	41 to 54	57 to 71	1 to 7	4 to 11	
Labor MD.4. With dummy head	63 to 73	74 to 92			Noise minimum for 90°, maximum for 180° incidence. 2 kc/s whistle produced at 40 m.p.h.
Labor MD.4	48 to 58	70 to 85			
Lustraphone LFV/59/H	80 to 90	96 to 100			4·5 kc/s whistle produced at 40 m.p.h.
S.T. & C. 4037	88 to 96	101 to 103			
S.T. & C. 4035	86 to 93	100 to 106			
S.T. & C. 4035 with 4001A windshield	83 to 86	94 to 98	1 to 7	3 to 11	Windshield least effective for 0°, most effective for 90° and 180° incidence
S.T. & C. 4032	87 to 94	97 to 102			
S.T. & C. 4032 and 4001A windshield	74 to 84	87 to 97	4 to 20	0 to 11	
S.T. & C. 4021	91 to 92	100 to 112			
S.T. & C. 4017	86 to 96	99 to 110			With wind at 90° incidence, silk in front of diaphragm flaps
S.T. & C. 4017 with Equipment Dept. windshield	72 to 75	92 to 97	11 to 24	3 to 13	Windshield most effective for 90° and 180° incidence
Philips EL.6040	68 to 85	88 to 89			

In applying these results, it should be borne in mind that the A.S.A. weighting is intended to give an indication only of the loudness of the noise; the annoyance value may well be very different. For example, in the Labor MD.4 microphone a strong 2 kc/s whistle is generated at 40 m.p.h. (64 km/h); the annoyance of such a noise is likely to be much greater than would be indicated by its loudness. For these reasons and for others given in a previous report[4] the figures should be used only to compare different microphones or conditions.

All the microphones tested are intended for speech transmissions, such as commentaries, but the distance from the mouth at which they are used varies with the different types, which are thus subjected to correspondingly different sound levels; for the purpose of calculation this difference has been taken into account. The distance from the commentator was assumed to be $2\frac{1}{8}$ in. (5·4 cm) for the two "noise-cancelling" microphones[5] — the B.B.C. type L.2 and the Labor type MD.4 — and 6 in. (15·2 cm) for the other instruments.

The various types of microphones have different frequency response characteristics, particularly at the bass. Wind noise is generally low-pitched in character and a microphone having a falling bass response for speech at the distance given will therefore have a lower wind-noise output than if the response were uniform or had been made so by equalisation. In the measurements given no equalisation has been used.

Pressure-gradient microphones, because of their mode of operation, usually have a much lower signal-to-wind-noise ratio than have pressure-operated instruments. With close-talking pressure-gradient microphones however, the position is more favourable for the bass response is attenuated to compensate for the rise in pressure-gradient at these frequencies. It will be seen from the table that the measured noise-level of the two instruments of this type, as expressed in terms of the wanted signal, is very low, with that of the type L.2 lowest of all. In the latter case the measurement confirms the effectiveness of the steps taken to render the instrument insensitive to wind noise[5]. It has been shown in field trials that this microphone can be used in wind speeds up to 20 m.p.h. (32 km/h) and, with the windshield mentioned in the table, at speeds exceeding 40 m.p.h. (64 km/h). It will also be seen that the presence of the artificial head, instead of reducing the wind noise by shielding the microphone from the air stream, usually increased the noise, presumably by causing turbulence.

Amongst the pressure-operated microphones the comparatively low noise of the Lustraphone type LFV 59H may well be due to the fact that the bass response falls rapidly at frequencies below 200 c/s.

Not only have the pressure-type microphones a higher wind noise level than the close-talking pressure-gradient microphones but it is very difficult to reduce the level in the former type by means of windshields of reasonable size.

5. CONCLUSION

The pendulum method of measuring wind noise does not generate ambient sound and can therefore be employed in the measurement of low levels of wind noise such as that produced by draughts. The time taken for a measurement, however, is considerable, hence the method is limited in practice to fairly low wind speeds where other techniques cannot be employed. A wind tunnel capable of delivering the air required at the highest velocities would be prohibitively large and expensive whilst the noise usually produced by the associated machinery makes it virtually impossible to carry out measurements at the lowest wind speeds of interest.

The whirling arm method enables wind noise to be measured at much higher air speeds than was formerly possible, and for the same velocities the time required for a set of measurements is less than with the pendulum method. The whirling-arm machine has also proved extremely valuable in the design of windshields for the type L.2 microphone. The main weaknesses of this device are that it is not easy to vary continuously the orientation of the microphone in the airstream in order to find the position giving maximum wind noise, and that it is not simple to use with microphones, such as the electrostatic type, which need a pre-amplifier. In practice, the lower limit to the air speeds at which it is profitable to use the machine is set by the structure-borne vibration produced by the driving mechanism.

6. REFERENCES

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